Chapter 2
DESCRIPTION OF PRIORITY WATER BODIES

REGIONAL RAINFALL PATTERNS

The hydrology of South Florida is strongly affected by it's climate, rainfall, and seasonal weather patterns. The region has a generally subtropical climate characterized by a long, hot, and humid wet season (May-October) and a relatively mild dry season (November-April). The wet season is characterized by high humidity, intense solar radiation, and unstable atmospheric conditions that result in frequent thunderstorms often accompanied by lighting and intense rainfall of short duration. Severe tropical storms such as hurricanes and tropical depressions also occur during the wet season. These storms can produce large amounts of rainfall over localized areas and cause extensive flooding. In contrast, the dry season is characterized by mild, dry weather. Frontal storms are dominant in the dry season, often bringing cool and occasionally freezing temperatures, and moderate amounts of low intensity rainfall. On average, South Florida receives about 53 inches of rainfall annually, 75 percent of which falls during the wet season (Shih, 1983).

Figure 2 provides estimates of mean monthly rainfall for Lake Okeechobee, the Everglades, and the Biscayne aquifer for the period of record, 1965-1995 (data from South Florida Water Management Model, version 3.6). Lake Okeechobee receives the lowest total average annual rainfall compared to the Everglades and the Biscayne aquifer with an average of 43.4 inches/year. June, July, August, and September are the wettest months, while November, December, and April are the driest. In contrast, the Everglades (the Water Conservation Areas and Everglades National Park) receive an average of 50.8 inches of rain each year. The wettest month is June and the driest month is December. The lower east coast of Florida (the Biscayne aquifer) receives, on average, the highest amount of rainfall, with an average of 59.2 inches recorded over the 1965-1995 period of record. Again, the wettest month is June and the driest month is December.

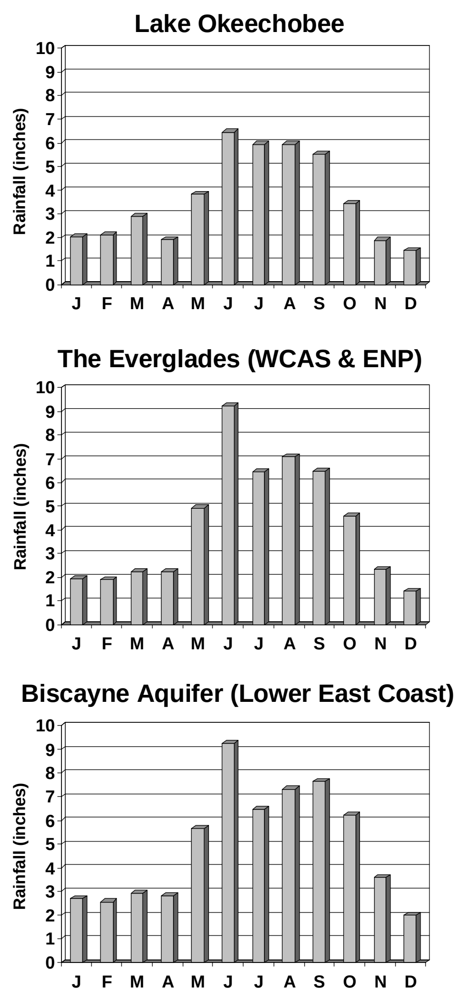

Figure 2. Mean Monthly Rainfall for Lake Okeechobee, the Everglades, and the Biscayne Aquifer (1965-1995). Source: Output of SFWMM 1995 Base Case (POR 1965-1995)

NATURAL VERSUS MANAGED HYDROLOGY

The following is a summary of the regional water budget derived from the 2000 Everglades Consolidated Report (SFWMD, 1999). Average annual water movements and storages in the Everglades from 1965 through 1995 under natural conditions (simulated by Natural Systems Model version 4.5) and under the 1995-base[1] managed conditions (simulated by South Florida Water Management Model version 3.5), are summarized in **Figures 3** and **4**.

Overland flows to the south and west from Lake Okeechobee have been entirely eliminated due to the construction of the levee and water-control structures. If these alterations had not been made, 868,000 acre-feet of water would have flowed overland from Lake Okeechobee to the Everglades and the Caloosahatchee Basin. Instead, 989,000 acre-feet of water is channeled to the south, west, and east for urban and agricultural supply and flood control. In addition, 216,000 acre-feet is discharged back into Lake Okeechobee to prevent regional flooding adjacent to the lake. Also, 149,000 acre-feet of water is discharge from Lake Okeechobee via the St. Lucie Canal.

Historic southerly overland flows from what is now the Everglades Agriculture Area, an area once dense with pond-apple and sawgrass, have also been eliminated. The Natural System Model (NSM) water budget (**Figure 3**) indicates that 157,000 acre-feet of net precipitation plus 900,000 acre-feet of surface water would have combined to form a southerly overland flow from this area into what is now the WCAs. The 1995-base managed condition (**Figure 4**) indicates no overland flow. All flows are now channelized for drainage, flood control, best management practices (BMP) makeup water, and water supply. Some of this water passes through the WCAs and is supplemented by Everglades water to meet urban and agricultural needs in the Lower East Coast Planning Area (172,000 acre-feet) and some WCA water seeps back into the EAA as groundwater (36,000 acre-feet).

Downstream of the EAA and Lake Okeechobee, the three WCAs are currently managed, in part, as large reservoirs for flood control for the Lower East Coast (LEC) Planning Area and the storage of EAA drainage water (**Figure 4**). This storage helps create a large groundwater flow (677,000 acre-feet) to the LEC Planning Area. This flow contributes to the huge movement of canal water lost to tide (2,843,000 acre-feet). This managed system is in sharp contrast to the NSM, which predicted large exchange of surface water, the lack of groundwater movement, and a low amount of freshwater flow to the Atlantic Ocean (**Figure 3**).

Finally, in the NSM water budget, the vast majority of all inflows and outflows in Everglades National Park are overland flows. This is not true for the 1995-base SFWMM water budget. Current inflows from the LEC Planning Area into Taylor Slough are only 32 percent of what was predicted to occur by NSM. The Shark River Slough outflow from Everglades National Park to the southwest, into the Gulf of Mexico, is 48 percent of what was predicted to occur by the NSM.

1. Note that the 1995-base is a fixed Everglades infrastructure, with stationary operational rules (circa 1995) and thus, is not indicative of the amount of actual freshwater delivered to Florida Bay by the C&SF Project from 1965 to 1995 (SFWMD, 1999).

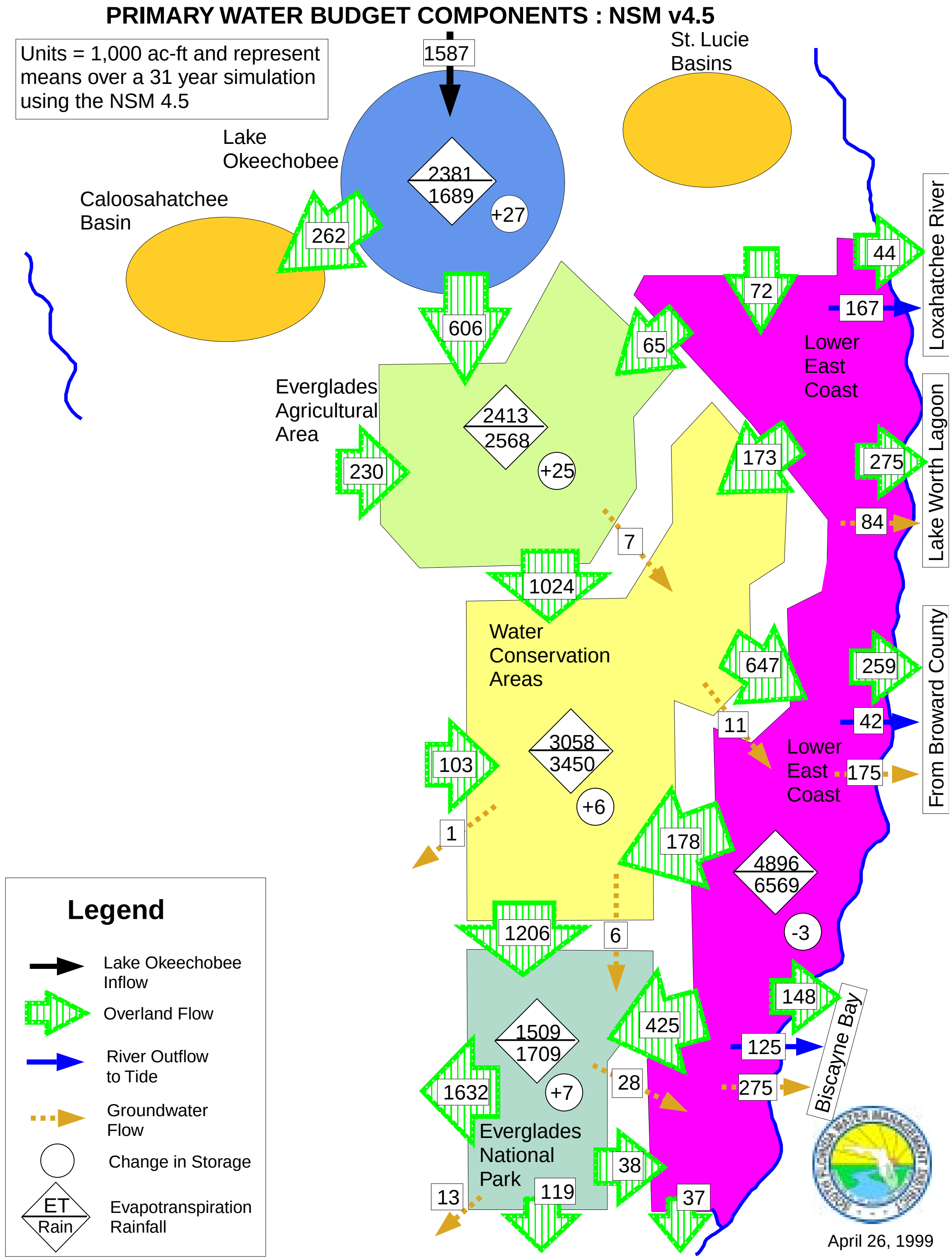

Figure 3. Primary Water Budget Components that Resulted from 31-Year Simulations of the Natural Systems Model, version 4.5 (SFWMD, 1999). Data are aggregated by major basins; flow values represent annual averages in thousands of acre-feet.

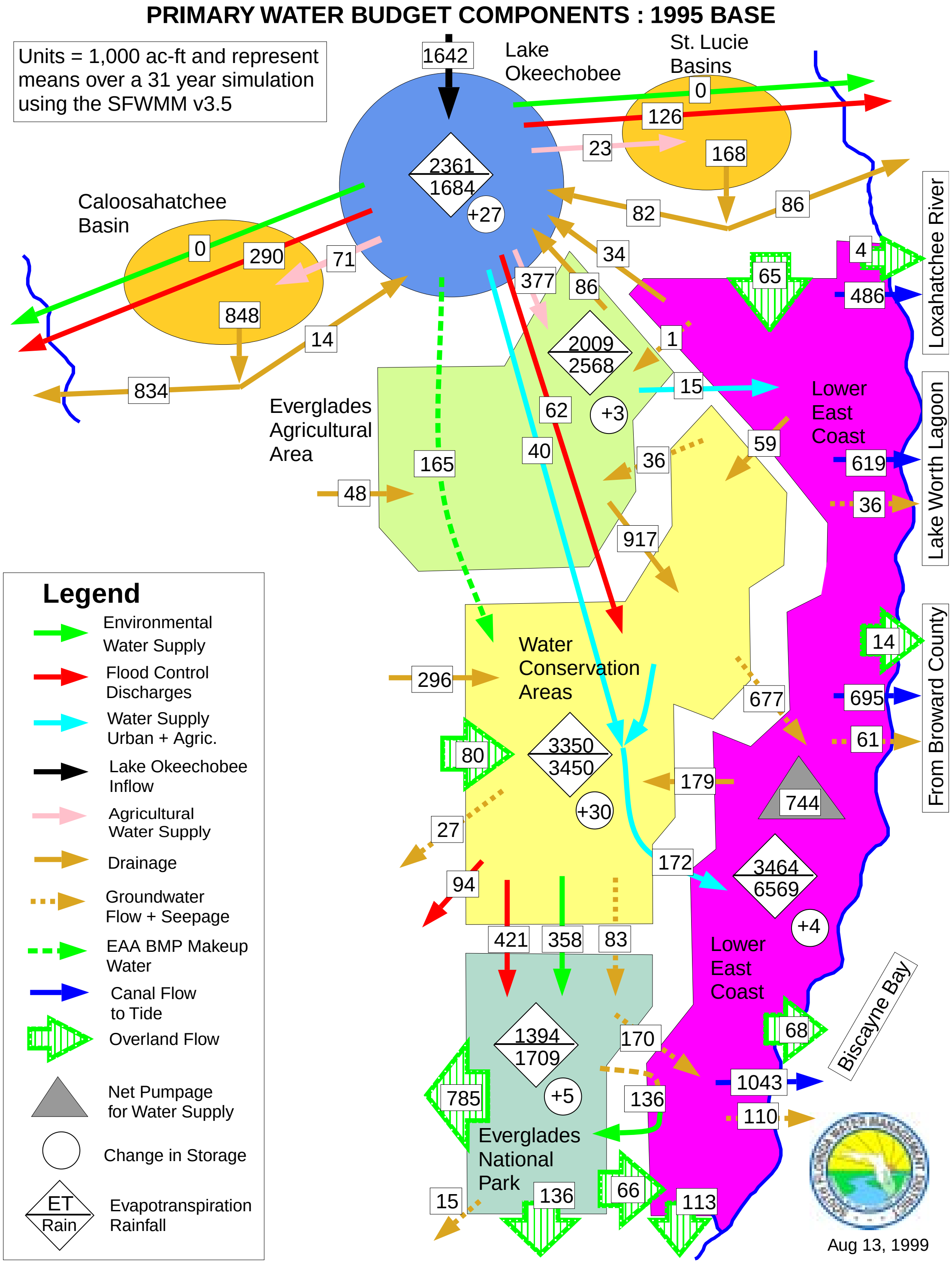

Figure 4. Primary Water Budget Components that Resulted from 31-Year Simulations of the South Florida Water Management Model Version 3.5 (SFWMD, 1999). Data are aggregated by major basins; flow values represent annual averages in thousands of acre-feet.

LAKE OKEECHOBEE

Major Features

Lake Okeechobee is a large, shallow, eutrophic lake located in south central Florida **(Figure 5**). The lake is often referred to as the "liquid heart" of South Florida's interconnected Kissimmee River-Lake Okeechobee-Everglades ecosystem. With a surface area of more than 730 square miles, Lake Okeechobee represents the third largest lake in the United States. The lake is a multipurpose reservoir developed as part of the Central and Southern Florida Project for Flood Control and other Purposes (C&SF Project). The lake provides the following:

- Water for surrounding lakeside communities
- Supplemental water supply for more than 6.5 million people living within the LEC Planning Area and the Caloosahatchee River Basin
- Supplemental irrigation water for agriculture in the LEC Planning Area (including the EAA), as well as in the Caloosahatchee River and C-44 Canal basins
- Supplemental water that can be delivered via canals to protect the Biscayne aquifer against saltwater intrusion
- A source of water for enhancement of fish and wildlife resources, for navigation and recreation benefits, and for Everglades National Park

The District and the United States Army Corps of Engineers (USACE) have the primary responsibility for management of water levels in the lake, the Florida Department of Environmental Protection (FDEP) and the District are the primary state agencies responsible for water quality protection, and the Florida Fish and Wildlife Conservation Commission (FFWCC) manages fish and wildlife resources.

Lake Okeechobee was formed approximately 6,000 thousand years ago (Hutchinson, 1957). Historic maximum water levels were estimated to range from 19.7 to 21.3 feet (Brooks, 1974). In its original condition, the lake was considerably larger than it is today and consisted of an extensive littoral marsh system extending to the north, west, and south of the lake. Construction of the levee system (Herbert Hoover Dike) around the lake and the lowering of lake levels from a maximum of 20 to 17 ft NGVD effectively isolated thousands of acres of marsh, creating a new littoral zone/marsh community in areas where it had not previously existed. This wetland area now occupies more than 20 percent (98,000 acres) of the total surface area of the lake and provides habitat for a wide variety of plant and animal communities, including a number of rare, threatened, or endangered species such as the snail kite, wood stork, West Indian manatee, and the Okeechobee gourd (SFWMD, 1993a). The littoral zone provides an important nursery ground and habitat for fish and other aquatic organisms. Migratory birds and waterfowl also utilize the littoral zone and open water areas of the lake as a resting area along the Atlantic flyway (Aumen, 1995).

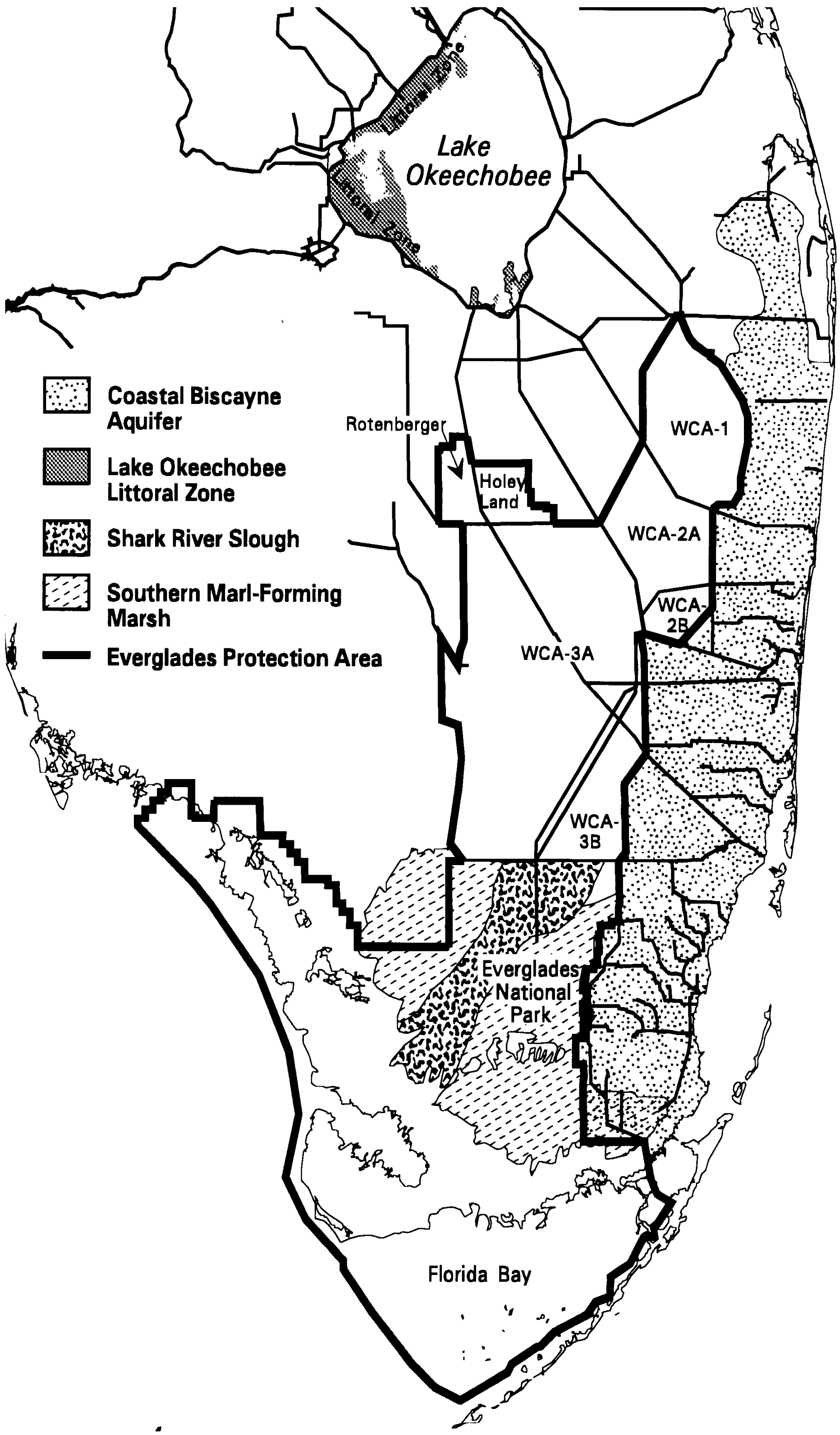

Figure 5. Priority Areas for Establishing Minimum Flows and Levels in South Florida.

Lake Okeechobee is also important to navigation and represents a recreational resource of regional importance. The lake is part of the Okeechobee Waterway connecting the east and west coasts of Florida. The lake also supports a nationally renowned sport fishery for largemouth bass, black crappie, bluegill, redear sunfish, and catfish. Recreational and commercial fisheries combined have an estimated value of more than $28 million dollars per year (Bell, 1987). The lake's littoral zone also supports significant wading bird populations and is an important waterfowl hunting area.

Resource Functions

The development of a minimum level and definition of significant harm for Lake Okeechobee focused on protecting four key water resource functions and achieving a balance among them (not listed in priority order):

- Provide water that can be used to maintain water levels in coastal canals and protect the Biscayne aquifer against saltwater intrusion
- Supply water and provide water storage for the Everglades
- Regionally important ecosystems in the lake littoral zone provide fish and wildlife habitat and support commercial and sport fisheries.
- Provide navigation and recreational use

Several combined hydrological impacts to each water resource function were also considered in defining significant harm for Lake Okeechobee:

- The water supply and storage function of the lake is impacted when water levels in the lake decrease to the extent that water deliveries can no longer be made to the LEC Planning Area to protect the Biscayne aquifer from the threat of saltwater intrusion, while at the same time meeting the demands of lake users who are under severe water shortage restrictions.
- Fish and wildlife habitat is damaged when water levels decrease to levels that impact the lake's littoral zone community and would take multiple years of normal rainfall to recover. Impacts associated with decreased water levels include the following:
  - Complete drying of the littoral zone
  - Loss of food resources and critical habitat for fish and wildlife, including threatened or endangered species
  - Invasion of the littoral zone by terrestrial vegetation and exotic species
  - Navigation and recreation functions of the lake are impacted when lake stages fall to levels that significantly restrict use of the Okeechobee Waterway and restrict

fishermen and boaters from access to the southern and western portions of the lake.

Water Resource Issues

The major water resource issues associated with management of Lake Okeechobee include the following:

Water Supply

Much of South Florida depends on Lake Okeechobee as its primary source of water supply during low rainfall periods. Future population growth, land use changes, and competing water supply needs will have significant effect on future water levels and water storage in Lake Okeechobee. Model simulations for 2010 show the increased likelihood of severe water shortages and water supply cutbacks within the Lake Okeechobee and LEC service areas (SFWMD, 1998). This reduced water supply has the potential to increase the problem of saltwater intrusion along Florida's lower east coast during dry periods.

Flood Protection

During 1997 and 1998, a number of extreme rainfall events increased water depths to levels which exceed the current regulation schedule and threatened the structural integrity of the levee system that surrounds the lake. To maintain an acceptable level of flood protection for communities that surround the lake, water levels during the hurricane season must be maintained at safe levels (<16.5 ft NGVD) that will not threaten the levee system.

Water Quality

Declining water quality and increased frequency of algal blooms have occurred in the lake as a result of increased nutrient loading from nonpoint sources of pollution originating from agricultural lands located north of the lake (Aumen, 1995; SFWMD, 1997a). This issue has been addressed through adoption and implementation of the *Lake Okeechobee Surface Water Improvement and Management* (*SWIM*) *Plan* (SFWMD, 1989, 1992, 1997a) and was not considered during development of MFLs.

Impacts to Estuaries

During periods of high rainfall, large regulatory releases of fresh water are made to the St. Lucie and Caloosahatchee estuaries. These discharges cause wide fluctuations in salinity within the inner estuary and impact estuarine biota (Haunert, 1988; Chamberlain et al., 1995)

Littoral Zone

The plants and animals in the littoral zone of Lake Okeechobee are stressed by extremes in water level, both at the high and low ends. Extreme high water levels flood the littoral zone with nutrient-rich water, may promote the expansion of cattails, and lead to declines in beneficial beds of submerged vegetation. Extreme low water levels render much of the littoral zone unavailable as habitat and appear to promote the expansion of exotic plants including torpedo grass and melaleuca. A primary issue related to defining a minimum water level for the lake is the determination of an appropriate water level regime (hydroperiod) that will maintain the ecological integrity of the littoral zone.

Exotics

Expansion of undesirable aquatic weeds and exotic plants (torpedo grass, melaleuca, hydrilla, water lettuce, and water hyacinths) have become a threat to the lake ecosystem because of their rapid expansion into areas once occupied by native species. These infestations hinder recreational use of the lake and require expensive chemical treatment (Aumen, 1995).

Water Management Features

Lake Okeechobee represents South Florida's most effective surface water storage area. Water levels within Lake Okeechobee are managed using a rule curve, or regulation schedule, while water allocation to downstream users is managed using a combination of the District's *Water Shortage Plan* (SFWMD, 1989) and *Supply-Side Management Plan for Lake Okeechobee* (Hall, 1991).

Lake Okeechobee Regulation Schedule

Water levels within Lake Okeechobee are managed according to a regulation schedule developed by the SFWMD and USACE (**Figure 6**). The schedule is designed to protect the integrity of the levees by maintaining a low water level (15.6 ft NGVD) during the wet season, providing storage capacity for excessive rainfall amounts, and preventing flooding in surrounding areas. Water levels are allowed to reach peak stages of 16.5 ft NGVD at the end of the wet season, storing water within the lake for the dry season. The schedule determines the timing and quantity of water that needs to be released from the lake when lake stages exceed certain flood control zones, which vary according to the season (**Figure 6**). The USACE operates the primary structures and navigation locks around the lake and is responsible for maintaining this schedule. The SFWMD operates and maintains the secondary water control structures and pump stations.

Several schedules have been implemented over the past 50 years in response to regional water storage and flood control needs. The lake has been regulated from a minimum of 12.5 to 14.5 ft mean sea level in the late 1940s, up to 15.5 to 17.5 ft NGVD in effect from 1979 to 1990. In 1991, the District proposed a number of modifications to the schedule known as Run 25 that allows for multiple water release zones to better control downstream discharges to the St. Lucie and Caloosahatchee estuaries. Included within the schedule are a series of pulse release zones (Levels I, II, and III) where smaller releases of fresh water are made to downstream estuaries in anticipation of the lake reaching levels that would require large regulatory releases that could damage downstream estuaries. More detailed descriptions of the history and operation of Lake Okeechobee's regulation schedule may be found in Trimble and Marban (1988); the *Lake Okeechobee SWIM Plan Update* (SFWMD, 1997a); and Neidrauer et al. (1997).

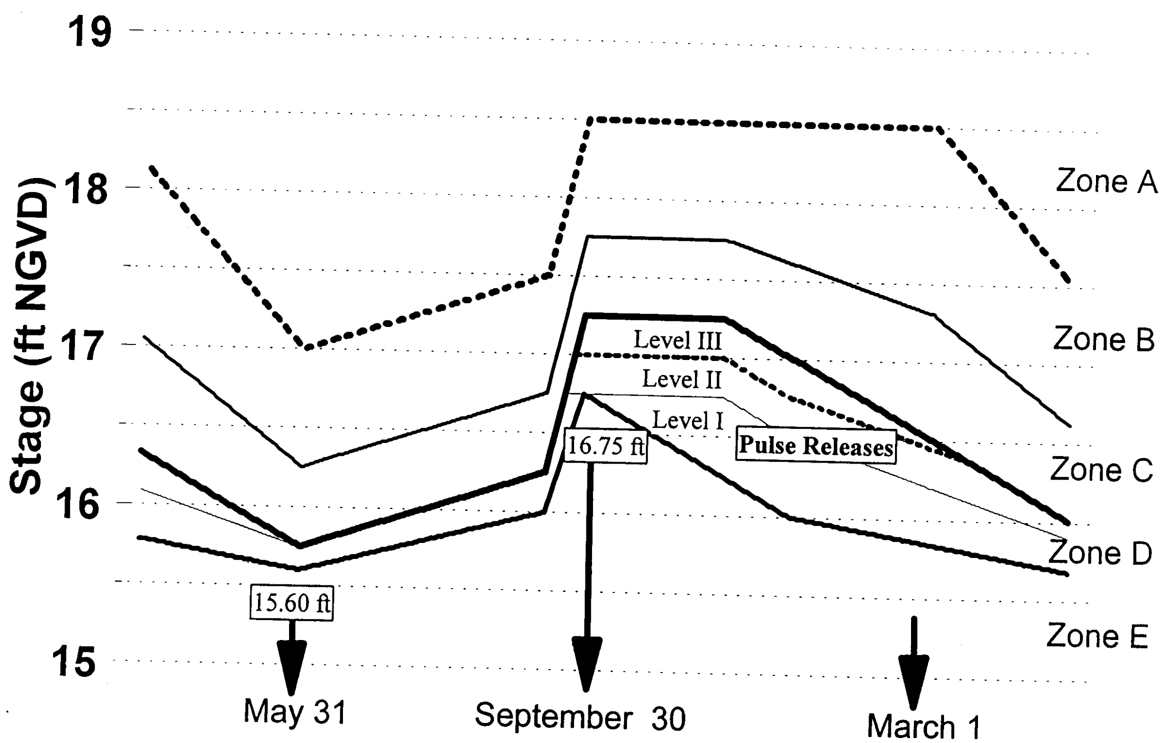

Figure 6. Lake Okeechobee Regulation Schedule Run 25.

In early 2000 the District and USACE expect to implement a new regulation schedule called the WSE (Water Supply and Environment) schedule. The WSE schedule uses information about tributary hydrologic conditions and climate forecasting models to guide lake operations. The goal is to minimize harmful effects of high water levels on the lake's littoral zone while not adversely impacting the regional water supply, flood protection, or downstream ecosystems. The decision features of the WSE schedule have been incorporated into the analyses of future scenarios that were conducted for the Central and Southern Florida Project Comprehensive Review Study (Restudy) and the *LEC Regional Water Supply Plan*. Although the effects of the WSE schedule were not evaluated during development of the Minimum Flows and Levels Technical Criteria, they will be incorporated the *Minimum Flows and Levels Recovery and Prevention Plan* as part of the *LEC Regional Water Supply Plan*.

Drought Management

During years of normal rainfall, the present Lake Okeechobee regulation schedule allows for an ample supply of water to be stored during the wet season for use in the subsequent dry season. Lake Okeechobee receives on average, approximately 43 inches of rainfall each year (period of record 1965-1995). This rainfall amount however, varies widely from year-to-year and from season-to-season. This variability tends to produce erratic and unpredictable rainfall conditions which can result in drought. In addition to this climatic variation, South Florida's rapid growth continually increases demand on the region’s available water supply during low rainfall periods. Historical records show that when lake levels fall below 11.0 ft NGVD, water shortage restrictions are imposed by the District along Florida’s lower east coast. Once below 11.0 ft NGVD, lake levels decline rapidly affecting the District’s ability to deliver water to downstream users, as well as affecting the ecology of the lake. More importantly, as water levels drop below 10.0 ft NGVD, structural limitations of the outlet structures make it increasingly difficult to withdraw water from the lake to send downstream and protect wellfields in Palm Beach, Broward, and Miami-Dade counties against saltwater intrusion.

To avoid extreme drawdowns that impact fish and wildlife communities in the lake, and South Florida’s water supply, the District developed a water supply management plan for Lake Okeechobee (SFWMD, 1987; Hall, 1991). The plan was developed in 1982 and serves as the basis for making water management decisions during periods of low rainfall. The primary objective of the plan is to ensure that adequate water remains within the lake for high demand periods, while still allowing the flexibility to respond to short-term needs of users who depend on the lake as their primary water source.

The basis of the plan is an allocation strategy which parcels out lake water based on weekly estimates of water use and demand for various user groups for the remainder of the dry season. Water availability is based on three factors in relation to the amount of water in storage: anticipated rainfall, lake evaporation, and downstream water needs for the balance of the dry season. Each factor used in the computation of weekly water allocations is based on the normal range of values expected to occur over the balance of the dry season. A critical end-of-dry-season (May 31) water level target of 11.0 ft NGVD was established for the lake. This criterion was selected based on the need to provide a backup supply of water within the lake that can be used to maintain freshwater heads in coastal canals which prevent saltwater intrusion of the coastal aquifer, and maintain storage capacity to meet reasonable needs of users. Once critical water levels (within Zones C or D described below) are reached, users have historically been subject to severe water restrictions. Water allotments are computed so that water levels will not fall below the May 31 target water level. The volume of water held in the lake between elevations 11.0 and 10.0 ft NGVD is approximately 327,000 acre-feet and represents the amount of water that is stored in the lake to protect the Biscayne aquifer from saltwater intrusion. The plan is based on six critical lake water level conditions that require various actions to be taken according to the severity of conditions (see **Table 1** below and **Figure 12** in Chapter 4).

Table 1. Definitions of Drought Conditions and Actions to be Taken.

Condition	Definition	Actions
Condition 1: **Watch**	The lake has roughly enough water supply in the lake to meet the water demands of a 1-in-5 year drought.	Publicize conditions at Governing Board meetings and in response to press releases
Condition 2: **Warning**	Enough water is stored in the lake to meet water use demands of a 1-in-3 year drought.	Begin mobilization of the District's Supply-Side Management Task Force; make personnel assignments for appropriate departments
		Notify and obtain approval from the USACE to enforce Lake Okeechobee water use restrictions should conditions worsen
		Contact key individual water users and organizations
Condition 3: **Implementation**	Water levels within this range indicate that, if normal rainfall and average water demands occur for the remainder of the dry season, the lake will fall below the critical 11.0 ft NGVD by May 31.	Implement Phases 1, 2, 3, and 4 water use restrictions for the LEC Planning Area as water levels fall within Water Supply Management Zones A, B, C, and D of the Lake Okeechobee Water Shortage Management Plan (**Figure 12**).
		All water releases from the lake will be based on the assumptions of average climatic conditions and average water use conditions with a May 31 target lake stage of at least 11.0 ft NGVD maintained.
		Mitigation actions approved by the District's Governing Board may be permitted as outlined in **Table 2**.
		The Executive Director of the District, if appropriate, may conduct public meetings of major Lake Okeechobee users.

The plan is based on a “live within our means” concept and requires water managers to prudently budget, save, and distribute water according to needs during a water shortage period. The plan provides a balanced water allocation strategy for all users that attempts to avoid severe drawdowns of the lake, and a method for holding a backup water supply in the lake for anticipated high demand periods and prevention of saltwater intrusion of Biscayne aquifer.

Operational decisions on water releases from Lake Okeechobee to downstream users are made jointly by the USACE and the District’s Governing Board after full consideration of local, regional, and environmental water resource issues. Under emergency drought conditions, the Governing Board has the operational flexibility to go below the target minimum level of 11.0 ft NGVD at the end of the dry season (April-June) to make critical water supply deliveries to the LEC Planning Area to protect the Biscayne aquifer from significant or serious harm caused by saltwater intrusion.

The plan also allows users to “borrow” water from their future water supply allocation, This borrowing provision places the risk-based decision on the water users (**Table 2**). Detailed procedures for determining the amount of water available in storage which could be allocated to users to meet dry season demands can be found in the S*upply-Side Management Plan* (Hall, 1991) that was adopted by the District’s Governing Board, has been in operation for seven years and provides an effective means to manage Lake Okeechobee when water supplies are limited.

Table 2. Water Supply Actions Available with Governing Board/Executive Director Approval.

MONTH	ZONE B	ZONE C
October	Shift[a] 1/3 February Allotment	Shift 2/3 February Allotment
November	Shift 1/3 March Allotment	Shift 2/3 March Allotment
December	Shift 1/3 April Allotment	Shift 2/3 April Allotment
January	Shift 1/3 May Allotment	Shift 2/3 May Allotment
February	Lower Target[b] to 10.75 ft NGVD	Lower Target to 10.5 ft NGVD
March	Lower Target to 10.5 ft NGVD	Lower Target to 10.25 ft NGVD
April	Lower Target to 10.25 ft NGVD	Lower Target to 10.0 ft NGVD
May	Lower Target to 10.0 ft NGVD	Lower Target to 9.75 ft NGVD

a. Shift means to add part of a future month's water allotment to the current month's amount.
b. Lowering the target increases monthly allotments but may result in very low lake levels going into the wet season.

THE EVERGLADES

Major Features

The Everglades is an internationally recognized ecosystem that covers approximately two million acres in South Florida and is the largest subtropical wetland in the United States. This area has been described as a vast sawgrass marsh, dotted with tree islands and interspersed with wet prairies and aquatic sloughs that historically covered most of southeastern Florida (Davis, 1943a). Today's remaining Everglades is comprised of the Water Conservation Areas (WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B), the Holeyland and Rotenberger Wildlife Management Areas (WMAS) and Everglades National Park, which also includes Florida Bay (**Figure 5**). WCA-2 and WCA-3 are also designated as the Everglades (Francis S. Taylor) WMA. WCA-1 is also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge. Everglades National Park and the WCAs were designated as Outstanding Florida Waters in 1978. They are the surviving remnants of the historical Everglades that once extended over an area approximately 40 miles wide by 100 miles long, from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay. This remaining area provides significant ecological, water storage, flood control, and recreational benefits to the region, as well as important habitat for wildlife of national significance.

Resource Functions

The development of minimum level criteria and a definition of significant harm for the Everglades focus on protection of six key water resource functions of this wetland system (not listed in priority order):

- Provide ground water recharge to prevent saltwater intrusion of the Biscayne aquifer, South Florida's primary drinking water source
- Provide food chains, substrates, and habitats necessary to support healthy Everglades wildlife, including threatened and endangered species
- Provide natural biological filtering and nutrient cycling, to trap suspended solids and metals in sediments, detritus and living tissue, and convert dissolved nutrients derived from rainfall, decomposition, and soil oxidation into biomass
- Provide aquatic refugia for Everglades fish, amphibians, aquatic invertebrates, and other wildlife during droughts
- Provide an Everglades ecosystem that is not degraded due to invasion by terrestrial woody vegetation and introduced exotics such as melaleuca
- Provide water flows that maintain salinity regimes and ensure survival of plant and animal communities in coastal estuaries

Several combined hydrologic impacts to each water resource function were also considered in defining significant harm for the Everglades as follows:

- Relationship between regional ground water levels and Everglades soils
- Everglades water levels and soil-plant community relationships
    - Peat formation and soil loss in the Everglades
    - Marl deposition
- Effects of low water levels on plant communities and wildlife habitat
    - Reduction in primary productivity
    - Changes in distribution and abundance of wetland plant communities
    - Changes in wildlife abundance and distribution
- Effects of water levels on fires
    - Effects of fire in the Everglades
    - Fire history

Water Resource Issues

A number of structural changes that have occurred to the regional ecosystem were considered during the development of MFL criteria for the remaining Everglades. Construction of the C&SF Project and large-scale urban and agricultural development have isolated large segments of the original Everglades from the natural system by canals and levees. More than half of the original system has been lost to drainage and development (Davis and Ogden, 1994). Today, these developed areas support a variety of land uses, ranging from intensively managed agriculture in the north (EAA) to rapidly spreading urban areas located east of the WCAs. The major water management issues that currently confront the Everglades ecosystem include the following:

Loss of Dynamic Storage and Spatial Extent

Loss of over 50 percent of the original Everglades wetlands, as a result of land development activities, has greatly reduced the water storage capacity of the ecosystem. Loss of the ability to store large volumes of water that historically moved as sheetflow across the Everglades landscape increases the system's susceptibility to the effects of flood and drought. Reduction in size of the Everglades also limits capacity of this ecosystem to support populations of wading birds, alligators, and panthers that once used the area in much greater numbers (Davis and Ogden, 1994; Science Subgroup, 1994; USACE, 1994).

Fragmentation of the Everglades

The historical system has been subdivided by construction of canals, levees, roads, and other facilities and has resulted in the loss of connections between the central

Everglades and adjacent transitional wetlands. Everglades wildlife communities and sustainability of the ecosystem may be impaired by this separation and isolation. Construction of canals and levees and impoundment of the WCAs have caused overdrainage of some areas and excessive flooding in other areas (USACE, 1994).

Changes in Timing, Distribution, and Quantity of Water

Altered timing and volume of discharges into, within, and between freshwater wetlands and estuaries have led to destruction, loss or degradation of native Everglades plant communities and associated wildlife habitat (SFWMD, 1992; Davis et al., 1994; Davis and Ogden, 1994).

Water Quality

High concentrations of phosphorus in waters that are discharged into the Everglades from the agricultural and urban areas may cause adverse changes in plant communities and wildlife habitat within the WCAs and potentially threaten the ecological integrity of Everglades National Park (SFWMD, 1992; Everglades Forever Act, Chapter 373.4592 F.S., 1994)

Invasion of Native Plant Communities by Exotic Species

Species such as melaleuca (Bodle et al., 1994), Australian pine, and Brazilian pepper have displaced native plants and degraded or destroyed wildlife habitat within over drained areas of the Everglades.

Impacts to Estuaries

Adequate quantity, timing, and distribution of water must be discharged from the freshwater areas of Everglades National Park and the WCAs downstream to Florida Bay and Biscayne Bay to maintain the biological integrity of these estuarine ecosystems (Boesch et al., 1993; Bancroft, 1993).

Water Conservation Areas

The WCAs are an integral component of the Everglades ecosystem and are important sources of water supply for South Florida. The WCAs, located south of Lake Okeechobee and west of the heavily urbanized lower east coast, comprise an area of about 1,350 square miles (**Figure 5**). Although originally part of the larger Everglades ecosystem, these remaining wetlands today serve multiple purposes, and provide the following (not listed in priority order):

- Detention areas for excess water discharged from Lake Okeechobee and flood control discharges from the EAA and portions of the LEC Planning Area

- Sources of water supply for LEC Planning Area agricultural lands and urban areas
- A means to recharge the Biscayne aquifer and retard saltwater intrusion in coastal wellfields
- Sources of water supply for Everglades National Park
- Important habitats for Everglades wildlife
- Public recreational uses
- Tribal uses by Seminole and Miccosukee Indians

Water Conservation Area 1

Physical Characteristics

WCA-1, designated as the Arthur R. Marshal Loxahatchee National Wildlife Refuge, is managed by the U.S. Fish and Wildlife Service (USFWS). WCA-1 covers an area of 221 square miles within Palm Beach County. The West Palm Beach Canal discharges agricultural drainage water into the north end of WCA-1 via Pump Station S-5A and the Hillsboro Canal and discharges via Pump Station S-6 into the southwestern portion. The area is enclosed by 58 miles of levees and provides storage for excess rainfall and runoff from the EAA. Ground level elevations range from 16 ft NGVD at the north end to 12 ft NGVD at the south end. The current minimum water level maintained within the perimeter canal is 14 ft NGVD. Below this level, water releases are not permitted unless water is supplied from another source. WCA-1 is an important source of water supply for urban areas in Palm Beach and Broward counties.

Management Issues

Historical data suggests that WCA-1 was originally a much wetter area and was part of the Hillsboro Lakes region of the Everglades (Davis, 1943a; Parker et al., 1955) Canal construction and drainage activities have eliminated overflow that once sustained prolonged hydroperiods within this region. Soils data (Gleason and Spackman, 1974), long-term vegetation studies (Alexander and Crook, 1984), and hydrologic models developed for the Everglades (Fenemma et al., 1994) also suggest that WCA-1 was generally much wetter prior to the construction of drainage canals. Based on this information, the USFWS proposed a change in the WCA-1 regulation schedule to provide deeper water, with longer hydroperiods, in an effort to restore the natural ecosystem functions of the original Hillsboro Lakes marsh system. The new schedule calls for maintaining a minimum water level of 14 ft NGVD and allows a maximum stage of 17.5 ft NGVD. This higher schedule will provide for the following:

- Allow higher water levels during wet years in the northern portion of the refuge
- Increase hydroperiod within the interior marsh to reduce the frequency of annual drying of the marsh

- Improve the timing of the dry season drawdown to benefit nesting wading birds
- Restore snail kite habitat
- Allow for more storage of water within the system during wet and normal rainfall years

Water Conservation Areas 2A and 2B

WCA-2A is an extensive sawgrass wetland that encompasses 210 square mile area (**Figure 5**) located within southern Palm Beach and northern Broward counties. It is the smallest of the three WCAs. Water levels in WCA-2A are controlled by a system of levees and water control structures which encircle the marsh. WCA-2A provides a variety of functions including the following:

- Aquifer recharge for protection against saltwater intrusion for east coast wellfields
- Flood protection for agricultural and east coast urban areas
- Preservation of Everglades wildlife, including threatened or endangered species
- Recreational opportunities (i.e. hunting, fishing, boating, and wildlife observation) for South Florida residents and visitors.

Management of water levels is the responsibility of the District in accordance with regulation schedules set by the USACE while the FFWCC is responsible for wildlife management. The water regulation schedule ranges from 13 ft NGVD at the end of the wet season (September 15) to 11 ft NGVD from February 1 through June 15 (dry season). The current minimum water level maintained within the L-35B and L-38 borrow canals is 10.5 ft NGVD, below which water releases are not permitted unless water is supplied from another source.

More than half of the surface water entering WCA-2A originates from the EAA (SFWMD, 1992). Canal inflow waters are highly mineralized and contain high concentrations of nitrogen and phosphorus resulting from the oxidation of organic peat soils within the EAA (SFWMD, 1992). The canals also convey water from Lake Okeechobee, which has been enriched by agricultural activities north of the lake. In 1961 the L-35B Levee was constructed across the southern portion of WCA-2 dividing the area into two smaller units, WCA-2A (173 square miles) and WCA-2B (37 square miles), in an effort to reduce water seepage losses to the south and to improve the water storage capabilities of WCA-2A.

This area has been severely affected by stabilized hydroperiods and high regulation schedules that were maintained during the late 1960s and 1970s. Wetlands in the central and southern portions of WCA-2A were flooded for extended periods, resulting in loss of tree islands and conversion of wet prairies to aquatic sloughs (Dineen, 1972; Worth, 1988). Changes have been made to the WCA-2A regulation schedule to mitigate adverse impacts of prior regulation schedules. Many of the ecological losses that occurred in the 1960s and 1970s, however, may take many decades to repair under the improved management of water levels. In the northeastern portion of WCA-2A, long-term discharges of waters with elevated nutrient concentrations through the S-10 structures, in combination with altered hydroperiod and fire, have caused significant changes in existing vegetation communities (Swift and Nicholas, 1987; Davis et al., 1994; Rutchey and Vilchek, 1994; Jensen et al., 1995). This area is currently a major focus of Everglades restoration efforts.

Water Conservation Areas 3A and 3B

Physical Characteristics

The largest of the WCAs, WCA-3, covers an area of 915 square miles, and is located in western Broward and Miami0Dade counties (**Figure 5**). The area is predominately a vast sawgrass marsh dotted with tree islands, wet prairies, and aquatic sloughs. A cypress forest fringes its western border along the L-28 Gap and extends south to Tamiami Trail.

In 1962, WCA-3 was divided into WCA-3A and WCA-3B (786 and 128 square miles, respectively) by construction of two interior levees (L-67A and L-67C). The levees were constructed to reduce water losses caused by levee seepage. WCA-3A is the only water conservation area that is not entirely enclosed by levees. The L-28 Gap allows overland flow to enter WCA-3A from the Big Cypress National Preserve and other western basins. WCA-3A is bisected by several major canals including the Miami Canal, which drains the EAA. Water also enters the area via the S-9 Pump Station, which drains urban areas located within western Broward County, and a combination of agricultural and WCA-2A sheetflow from the S-11 structures. Management of water levels within WCA-3A and WCA-3B is the responsibility of the District in accordance with regulation schedules set by the USACE. Wildlife management is delegated to the FFWCC under lease from the SFWMD.

Water levels in WCA-3A are regulated from 9.5 to 10.5 ft NGVD. Water levels in WCA-3A are estimated by averaging data from three gauges: 3A-3, 3A-4 and 3A-28. During droughts, a minimum elevation in the borrow canal of 7.5 ft NGVD is observed. Below this elevation, no further releases are permitted from WCA-3A unless a supply of water from another storage area is transferred to WCA-3A (USACE, 1992).

Management Issues.

WCA-3A serves a variety of functions including the following (not listed in priority order):

- Aquifer recharge and protection against saltwater intrusion for east coast urban areas
- Flood protection for agriculture and east coast urban areas

- Habitat for the preservation of Everglades wildlife, including threatened or endangered species
- Recreational opportunities (i.e. hunting, fishing, boating, and wildlife observation) for South Florida residents and visitors
- A source of high quality inflow water for Everglades National Park

The initial WCA-3A operating schedule and configuration of water management structures has caused the overdrainage of northern WCA-3A, resulting in loss of organic soils, tree islands, and wet prairies due to soil subsidence and peat fires (Zaffke, 1983; Schortemeyer, 1980). Satellite map imagery shows that much of northern WCA-3A is in transition from wetlands to brush vegetation (primarily wax myrtle and willow) and large areas of eastern WCA-3A are being invaded by cattails.

Construction of Alligator Alley, and the associated borrow canal, have restricted sheetflow to the south. The location and design of the Miami Canal have contributed to the overdrainage of the northern end of WCA-3A. Water discharged through the S-8 Pump Station moves south in the canal at a greater rate than historic sheetflow. Additional environmental enhancement structures have been added in the Miami Canal, such as S-339 and S-340 in the Miami Canal, to induce more sheetflow through the marsh, but the addition of these structures has not solved the problem. Sheetflow within WCA-3A must be restored, especially in critically impacted northern areas, to protect the natural resources. Water levels in the northern portion should be raised during dry periods to reduce the incidence of severe muck fires. In contrast, construction of the L-29 Levee across the southern end of WCA-3 in 1962 interrupted the southerly flow of water to Everglades National Park causing water ponding and extended hydroperiods at the south end of WCA-3A. Both of these conditions are considered harmful to Everglades plant communities and wildlife habitat (Zaffke, 1983).

Holey Land and Rotenberger Wildlife Management Areas

Physical Characteristics

Together, the Holey Land and Rotenberger WMAs comprise approximately 59,000 acres consisting of sawgrass, sawgrass/brush, and tree islands (**Figure 5**). These areas are state owned and are managed by the Florida Fish and Wildlife Conservation Commission (FFWCC) for deer, hog, and waterfowl hunting. Wading birds and a host of other nongame species of Everglades wildlife also utilize the area.

Major Issues

The Holey Land and Rotenberger WMAs have been identified as areas in need of hydrologic restoration. Similar to northern WCA-3A, the Holey Land and Rotenberger WMAs have experienced excessive drying, repeated muck fires, soil subsidence, and severe damage to tree islands resulting from lower water levels, soil oxidation, and wildfires. Drier conditions have allowed Everglades wetland communities to be replaced by woody terrestrial species such as salt bush and wax myrtle. Diversion of nutrient-enriched canal water has also allowed cattails to replace native vegetation. In 1983, a Memorandum of Understanding was entered into by the FDEP, the Board of Trustees of the Internal Improvement Trust Fund, the FFWCC, and the SFWMD to establish a process for the implementation of a plan to restore Everglades values associated with the Holey Land and Rotenberger WMAs and provide for the establishment of water regulation schedules that will simulate more natural hydroperiods. In June 1990, the District and the FFWCC entered into an agreement detailing the initial operational schedule for the Holey Land WMA that will improve hydroperiods for both the Holey Land WMA and WCA-3A (SFWMD, 1992).

Everglades National Park

Physical Characteristics

Everglades National Park encompasses 2,150 square miles of freshwater sloughs, sawgrass prairies, marl-forming wet prairies, mangrove forests, and saline tidal areas located at the southern end of the Florida peninsula (**Figure 5**). The topography is extremely low and flat, with most of the area below 4 ft NGVD, while highest elevations (6 to 7 ft NGVD) occur in the northeastern portion of the park. Schomer and Drew (1982) recognized five hydrologic/physiographic subzones located within Everglades National Park (**Figure 7**). These include the following areas:

- Shark River Slough
- Rocky Glades
- Broad River/Lostman's River
- Coastal mangrove swamps and lagoons
- Cape Sable area

Everglades National Park was formally established by Congress in 1934 to preserve the unique ecology of the Everglades. It was designated by the United Nations as a World Heritage Site in 1979. It has also been named as a Federal Wilderness Area, an International Biosphere Reserve, and a Wetland of International Significance. Today Everglades National Park represents the second largest national park in the United States and is also considered one of the nation's ten most endangered parks.

Major Issues

The quantity, quality, distribution, and timing of water flows into the Everglades National Park must be sufficient to maintain and restore the full abundance and diversity of the native floral and faunal communities throughout the Everglades National Park. Water supply is critical to the continued survival and function of Everglades National Park and Florida Bay. Changes in the distribution, timing, and volume of water inflows to Everglades National Park and subsequent changes in hydroperiod have been linked to the decline of the Everglades National Park’s biological resources.

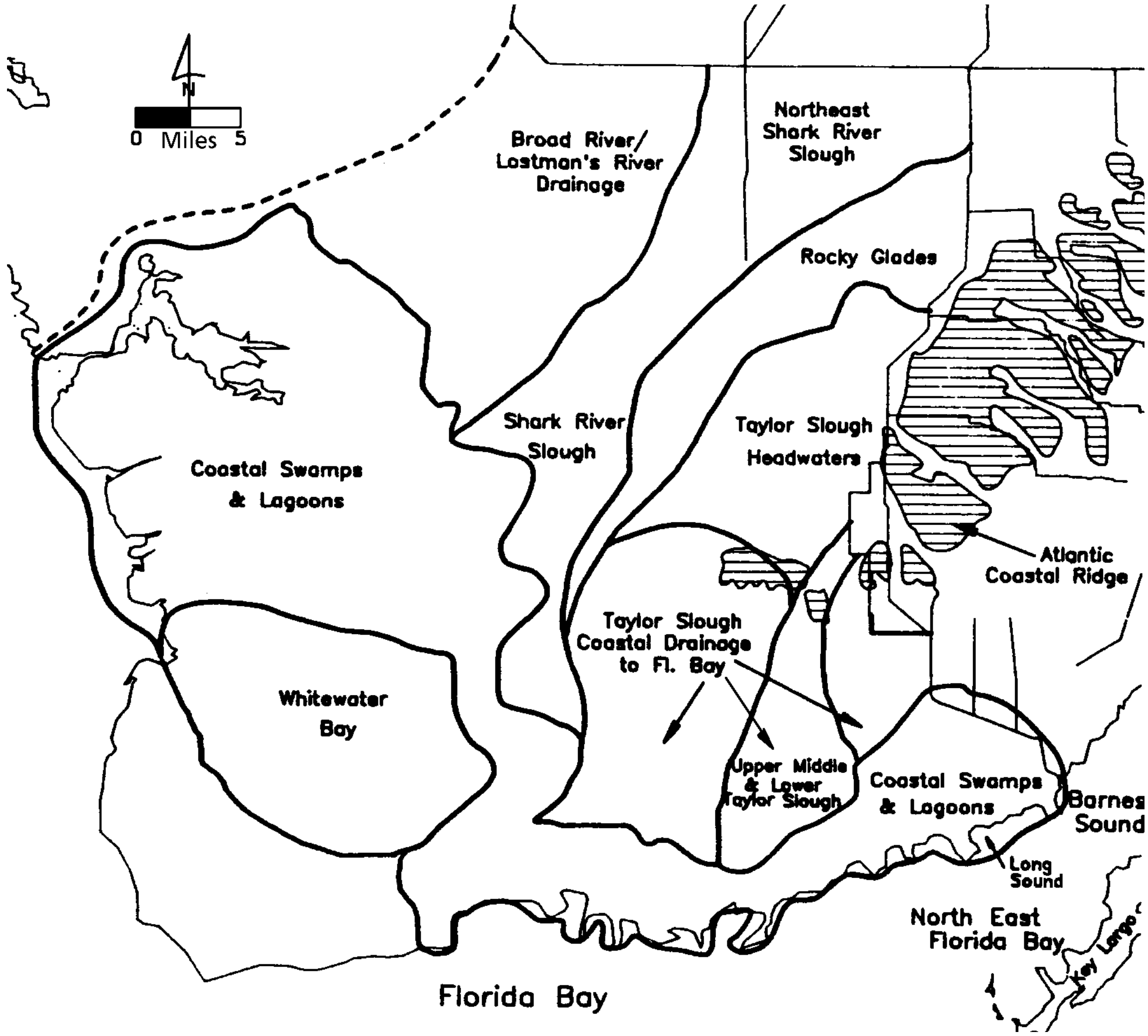

Figure 7. Hydrologic and Physiographic Provinces of the Everglades National Park Study Area. (Modified from Schomer and Drew, 1982; Davis, 1943a; White, 1970; Puri and Vernon, 1964.)

Shark River Slough

Physical Characteristics

This area of Everglades National Park consists of a broad southwesterly arc of continuous wetlands, interspersed with sawgrass strands, open water sloughs, wet prairies, and tree islands extending from Tamiami Trial to the mangrove estuaries of Florida Bay (**Figure 7**). Underlying soils are moderate to shallow depth Loxahatchee peat. Shark River Slough occupies the center of the Everglades trough and has been described as a wide, slightly concave depression in the underlying limestone (White, 1970). The slough represents the principle watershed for Everglades National Park and provides the primary source of freshwater inflow for downstream Florida Bay estuaries.

Management Issues

Uncontrolled flow to Shark River Slough was impeded by construction of the first east-west road (Tamiami Trial) and the borrow canal built across the Everglades in 1928. Construction of the eastern perimeter levee and impoundment of the upstream WCAs as part of the C&SF Project essentially eliminated natural sheetflow to Shark River Slough by the mid 1950s.

Current flow patterns to Everglades National Park are highly influenced by upstream management of the WCAs and pumping of agricultural and urban drainage canals to the north and east. Water level declines have occurred throughout the park, with major declines occurring along the eastern boundary of the park in northeast Shark River Slough, the Rocky Glades, and northern Taylor Slough. During wet years, western Shark River Slough receives large regulatory releases from the upstream WCAs. These high flows substantially alter natural water patterns and transform the area from a transitional marl-forming wetland to the main flowway. A rainfall-based plan for water deliveries to Everglades National Park will allow reintroduction of sheetflow and restoration of more natural water depths and hydroperiods within eastern and western Shark River Slough.

Southern Marl-Forming Marshes

Physical Characteristics

These wetlands are characterized by the formation of marl soils (also known as calcitic mud). Marl is formed by the precipitation of calcite by blue-green algae in submerged algal mats (periphyton) under shallow water/short hydroperiod conditions. Marl-forming marshes occur on the eastern and western margins of Shark River Slough, as well as in Taylor Slough and the Rocky Glades (**Figure 7**). These wetlands occur at a slightly higher elevation than Shark River Slough and exhibit corresponding shallow water depths and shorter hydroperiods. These communities have also been called the southern coastal marsh prairies (Davis, 1943a), southeast saline Everglades (Egler, 1952), marl Everglades, marl prairies (Harper, 1927; Werner, 1976; Olmsted and Loope, 1984), *Muhlenbergia* prairies (Olmsted et al., 1980), and southern marl marshes (Davis et al., 1994). The dominant vegetation is muhly grass and sawgrass.

Management Issues

Agricultural and urban development in the east Everglades has resulted in a direct loss of marl-forming wet prairies through conversion of marshes to farmland and housing projects. Construction of the C&SF Project and the South Dade Conveyance System has resulted in compartmentalization of the remaining marl prairie/Rocky Glades wetland system through a network of levees and canals designed to drain the area during wet periods. This water management system has altered hydropatterns and lowered water tables throughout the eastern portion of Everglades National Park and reduced flows to Florida Bay.

Presently, large areas of the Rocky Glades and adjacent marl prairies remain dry under average rainfall conditions, as compared to 7 to 10 months inundation under natural conditions. Shortened hydroperiods reduce wetland aquatic productivity. They reduce fish and invertebrate populations, which in turn limit foraging opportunities for wading birds and other Everglades wildlife. Lowered water levels and shortened hydroperiods also alter Everglades fire regimes and allow invasion by woody plants, exotics, and other terrestrial species.

COASTAL BISCAYNE AQUIFER

Major Features

The principal ground water resources for the LEC Planning Area are the surficial aquifer and the Biscayne aquifer. These two ground water systems provide most of the fresh water for public water supply and agriculture within the study area. The Biscayne aquifer is an unconfined aquifer and a component of the Surficial Aquifer System underlying most of southeast Florida as shown in **Figure 8**. These ground water systems provide the following:

- A major source of drinking water for more than 6.5 million people living in urban areas along Florida’s east coast
- A source of water for local wells, canals, and lakes
- A major source of irrigation water for agriculture
- A source of water to replenish regional wetlands and provide base flow to estuaries such as Biscayne Bay and Florida Bay

The Biscayne aquifer is composed of units and formations principally deposited during the Pleistocene epoch, or Great Ice Age. This interval of geologic time was a period of climatic instability where great glaciers advanced and retreated across the continents. As the glaciers advanced, sea level declined and large areas of South Florida became exposed as dry land. Deposition during this time occurred due to dune building and formation of freshwater limestones. As the glaciers melted, sea levels increased and eventually submerged the southern peninsula, creating a highly productive, shallow marine environment. During this time period, marine deposits dominated the composition of the Biscayne aquifer. Typical marine deposits from these high sea level stands occur throughout South Florida and include the coral limestones on Key Largo and the oolitic ridge along the coast (Hoffmeister, 1974).

The major geologic deposits that comprise the Biscayne aquifer include: the Miami Limestone, the Fort Thompson Formation, the Anastasia Formation, and the Key Largo Formation. The base of the Biscayne aquifer is generally the contact between the Fort Thompson Formation and the underlying Tamiami Formation of Plio-Miocene age. However, in places where the upper unit of the Tamiami Formation contains highly permeable limestones and sandstones, these zones would also be considered part of the Biscayne aquifer if the thickness exceeds 10 feet (Fish and Stewart, 1991).

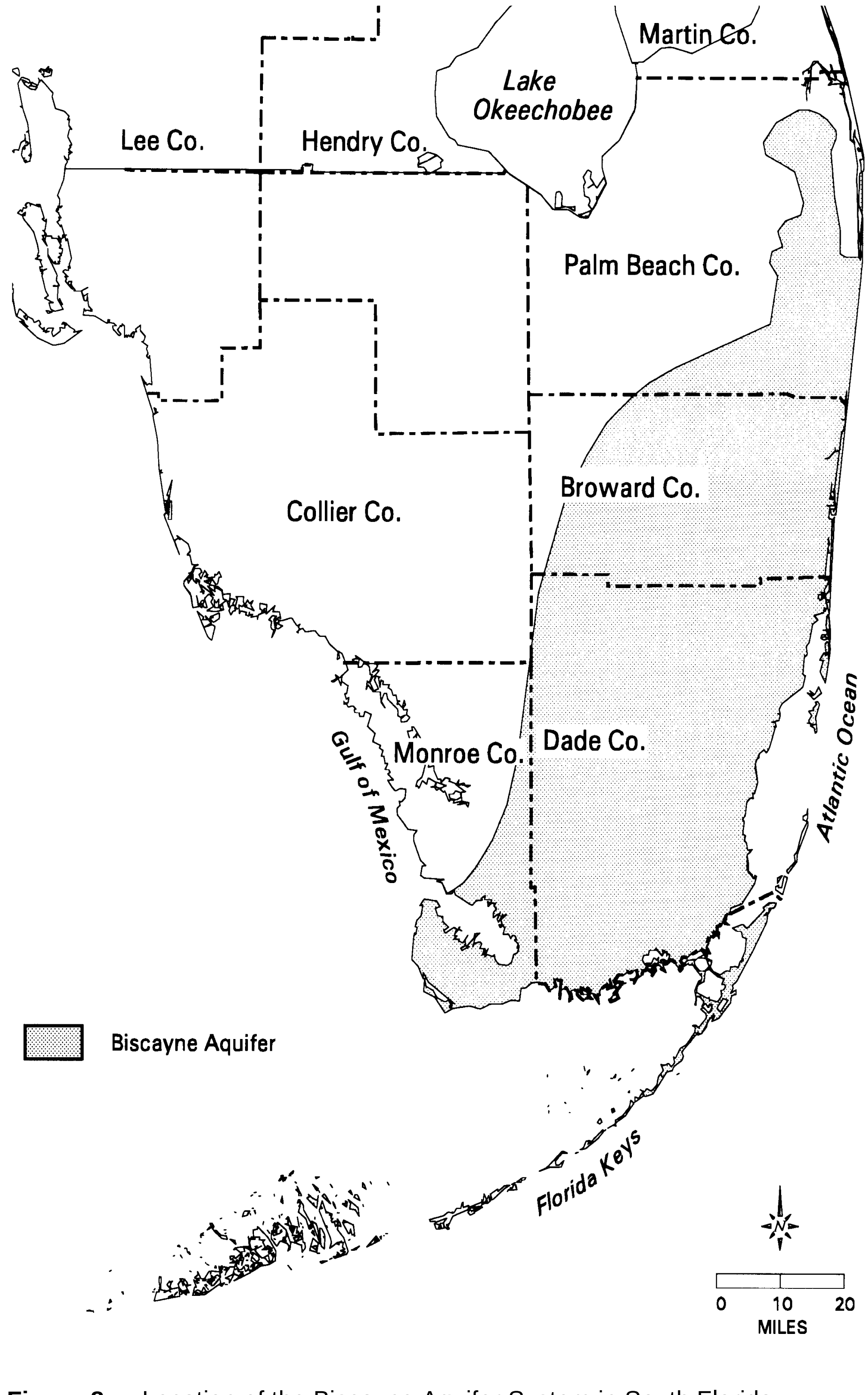

Figure 8. Location of the Biscayne Aquifer System in South Florida.

The Biscayne aquifer is composed of interbedded, unconsolidated sands and shell units with varying thicknesses of consolidated, highly solutioned limestones and sandstones (Shine et al., 1989). In general, the Biscayne aquifer contains less amounts of sand and a greater percentage of solution cavities in the limestone than the Surficial Aquifer System. The Biscayne aquifer is one of the most permeable aquifers in the world and has transmissivities in excess of 7 million gallons per day, per foot of drawdown (Parker et al,. 1955). Due to its regional importance, it has been designated as a sole source aquifer by the U.S. Environmental Protection Agency (USEPA) under the Safe Drinking Water Act and is, therefore, afforded stringent protection.

Resource Functions

The following water resource functions were considered in the development of minimum water level criteria for the Biscayne aquifer:

- It represents the primary source of water supply for urban and agricultural users within the LEC Planning Area.
- It provides base flow to important estuaries such as Biscayne Bay and Florida Bay during low rainfall years.
- Maintenance of appropriate ground water levels within the Biscayne aquifer prevents saltwater intrusion.

The hydrological impacts to these water resource functions that were considered in defining significant harm for the Biscayne aquifer were as follows:

- When ground water levels decline, saltwater intrusion begins to occur within the aquifer.
- The head of ground water that is needed to halt the further advance of saltwater intrusion can be determined using a number of different approaches based on theoretical analyses, and results of field investigations and modeling studies.
- Ground water levels in the Biscayne aquifer can be regulated by controlling water levels in coastal canals.

The definition of significant harm for the Biscayne Aquifer system could be based on consideration of many possible sources of damage. In developing MFLs criteria for the Biscayne aquifer, emphasis was placed on factors that are within the jurisdictional authority of the District, can be controlled and monitored on a regional scale, and can be controlled and tracked using existing District permitting capabilities, structural features, and extensive monitoring network.

Saltwater intrusion was chosen as the primary criterion of interest for defining significant harm to the Biscayne aquifer for the following reasons:

- Saltwater intrusion represents a major threat to South Florida's regional water supply system.

- The District has the responsibility to protect the resource from saltwater intrusion through operation and maintenance of the structures, pump stations, and canals that comprise the C&SF Project.
- Saltwater intrusion is most likely to be directly influenced by changes in aquifer levels.

On a regional scale, it is the responsibility of the District to regulate canal levels and salinity structures along the lower east coast to prevent saltwater intrusion. Saltwater intrusion is often a regional phenomenon that can occur over many miles of coastline and impact numerous users across multiple political boundaries. On a local scale, consumptive uses and drainage systems are regulated by the District in a manner that restricts the net annual inland movement of the saltwater–freshwater interface. This movement is influenced by a number of factors including individual or cumulative impacts of drainage projects and/or withdrawals from wellfields. Surface water management systems are issued permits to ensure that postdevelopment peak runoff rates do not exceed predevelopment rates.

Major Issues

The principal issue regarding development of minimum level criteria for the Biscayne aquifer is saltwater intrusion, which is the contamination of the aquifer by a westward-moving front of salt water. Along the eastern edge of the Biscayne aquifer, both fresh water and salt water are in contact as shown in **Figure 9**. When ground water levels are lowered inland adjacent to this saltwater–freshwater interface, salt water potentially

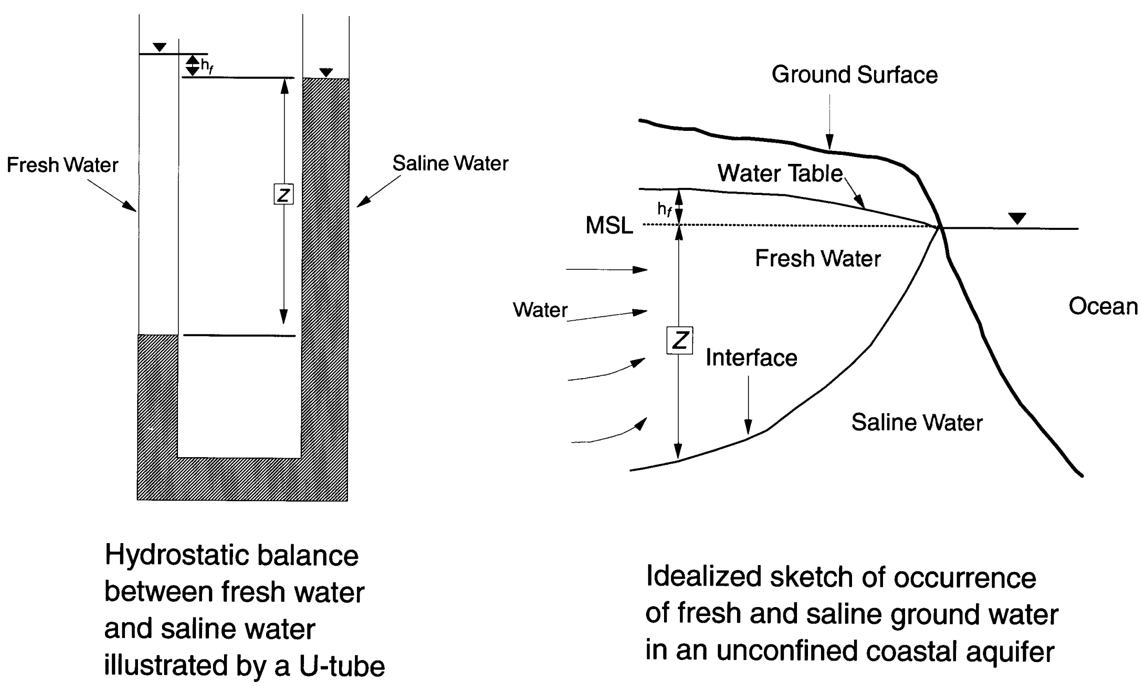

Figure 9. Gyphen-Hertzberg Relationship Showing Freshwater/Saltwater Interface Along the Lower East Coast of Florida.

can move inland, replacing fresh water with saline water. Once the higher density saline water has migrated inland, it remains there for long periods of time and may cause a long-term, or perhaps permanent loss, of that portion of the aquifer as a source of fresh water. Along the lower east coast, lowering of the ground water table due to overdrainage and increased wellfield withdrawals has allowed salt water to invade and contaminate the Biscayne aquifer during periods of drought (Parker et al., 1955). Saltwater intrusion of the Biscayne aquifer is considered as one of the most serious threats to South Florida's coastal water supply.

In conjunction with the District's Consumptive Use Permitting program, saltwater intrusion is monitored along the lower east coast by collecting samples from a series of monitoring wells located along the saltwater–freshwater boundary near the coast. When analysis of samples from one or more of these wells indicates that chloride levels have increased beyond an established threshold, appropriate management actions are taken, based on the District's *Water Shortage Policy*, to reduce withdrawals or increase the amount of water delivered from the regional system in the vicinity of those wells. Water levels in coastal canals are a direct indicator of water levels in the adjacent aquifer and the potential that saltwater intrusion may occur. Although there is not an exact relationship between water levels in the canals and chloride levels in the monitoring wells, low water levels in canals are an indicator of future problems. Historical data indicate that some areas that have had low water levels in the adjacent canals for extended periods (more than six months) have later experienced significant saltwater intrusion.

IDENTIFICATION OF BASELINE CONDITIONS FOR WATER RESOURCE FUNCTIONS

Definitions

Once the water resource functions to be protected by a specific minimum flow or level have been identified, these functions are then evaluated to determine their applicable baseline or desired condition. These considerations are set forth in Section 373.0421(1)(a), F.S. They allow water management districts, when setting MFLs, to consider changes and structural alterations that have occurred to a water resource. Likewise, Section 373.0421(1)(b), F.S., recognizes that certain water bodies no longer serve their historical function and that recovery of these water bodies to historical conditions may not be feasible. Allowances are provided to account for loss of historical functions. These provisions are discussed below to determine if they apply to minimum levels that are proposed for the Everglades, Biscayne aquifer, and Lake Okeechobee.

Considerations

Section 373.0421(1)(a), F.S. requires the consideration of changes and structural alterations to watersheds, surface waters, and aquifers and the effect such constraints or alterations have had on the hydrology of the area. The important qualifier to this consideration is it *cannot* be used to allow significant harm to be caused by withdrawals.

This consideration, which relates to the level of protection that is provided by the minimum flow or level, requires the Governing Board to consider that, due to human activities, some water resources are not performing their historic or natural functions.

In establishing a minimum flow or level for an affected area under this consideration, the Governing Board may therefore decide not to protect the resource for a purpose it served in the past or to the extent it once functioned. The statute limits, however, the consideration of changes in functions caused by withdrawals. Likewise, the Governing Board may choose to define significant harm based on reference to unimpacted systems.

Exclusions

Section 373.0421(1)(b) also provides exclusions for setting MFLs. These statutory exclusions explicitly do not apply to the Everglades Protection Area. The Everglades Protection Area is defined in Section 373.4592(2)(h) F.S., as “Water Conservation Areas 1, 2A, 2B, 3A and 3B, the Arthur R. Marshall Loxahatchee National Wildlife Refuge, and Everglades National Park.” As a result of this prohibition, District staff only utilized the considerations in Section 373.0421(1)(a) F.S., in developing minimum levels for these areas. The first exclusion in subsection 373.0421(1)(b)1 F.S. recognizes that certain water bodies no longer serve their historic hydrologic functions, and that recovery of these areas may not be economically or technically feasible and could cause adverse environmental or hydrologic impacts. In conclusion, the exclusion provides that water management districts may determine that setting a minimum flow or level for such a water body based on its historical conditions is not appropriate.

District staff recognizes that the exclusion in 373.0421(1)(b)1, regarding historic functions, could be considered in establishment of minimum levels for Lake Okeechobee, the Holey Land and Rotenberger WMAs, and the coastal Biscayne aquifer. All of these areas have been greatly altered by development and require flood protection. Recovery of levels in Lake Okeechobee and the coastal Biscayne aquifer to historic levels, on a regional scale, would be technically and economically infeasible, due to the current level of flood protection and development which exist in these two areas. In addition, adverse hydrologic impacts to urban areas in Miami-Dade, Broward, and Palm Beach counties and agricultural areas surrounding Lake Okeechobee may also prohibit the recovery of these areas to historic conditions.

Although it appears that the exclusion may be applicable, District staff have determined that the considerations in Section 373.0421(1)(a) F.S. adequately address the changes and alterations in water resource functions applicable to these areas. As a result, there appears to be no basis to invoke the exclusion in subsection (1)(b)1 or to document the economic and technical feasibility of recovery.

The remaining exclusions in subsections 373.0421(1)(b)2 through 3, F.S., are not applicable to Lake Okeechobee, the Holey Land and Rotenberger WMAs, and the Biscayne aquifer, since these exclusions only pertain to water bodies less than 25 acres in size or constructed water bodies. As stated above, these exclusions cannot statutorily be applied to the Everglades Protection Area.

Water Resource Considerations

During the development of MFLs criteria for Lake Okeechobee, the Everglades, and the Biscayne aquifer, District staff considered a number of structural changes or alterations that have occurred within these priority water bodies, as well as the constraints such changes have placed on the hydrology of the region. Since the considerations in Section 373.0421(1)(a), F.S., adequately address baseline conditions of the Biscayne aquifer and Lake Okeechobee, District staff do not recommend that the exclusions established in subsection (1)(b) of Section 373.0421, F.S. be applied. Changes, alterations, and constraints on these resources, as covered by statute, are listed below by area.

Lake Okeechobee

- Historic water levels for the lake were estimated to range between 16 and 21 ft NGVD. Early drainage efforts lowered the lake connecting it to the Caloosahatchee River. Catastrophic hurricanes of the 1920s and 1940s prompted the federal government to improve flood protection for the region. In 1948, Congress authorized construction of the C&SF Project which included impoundment of the lake with the 38 ft NGVD Herbert Hoover Dike. This structure was completed in the 1960s, resulting in the regulation of all lake inflows and outflows with the exception of Fisheating Creek.
- The C&SF Project recognizes that the lake is a multipurpose, regional resource. Authorized project purposes included flood control, irrigation, municipal and industrial water supply, enhancement of fish and wildlife, navigation, and recreation.
- To maintain an acceptable level of flood protection for communities that surround the lake, water levels during the hurricane season must be maintained at safe levels (less than 16.5 ft NGVD) that will not threaten the structural integrity of the levee system, as determined by USACE regulations.
- Another constraint placed on the lake is the amount of water that can be stored for water supply. When lake levels fall below 10.5 ft NGVD, structural limits of the outlet structures make it increasingly difficult to withdraw water to send to downstream users and protect the coastal aquifer from the threat of saltwater intrusion. Theoretically, 9.5 ft NGVD represents the level below which water can no longer be withdrawn from the lake to send to the LEC Planning Area.
- In its original condition, the lake was considerably larger than it is today and consisted of an extensive littoral marsh system extending to the north, west, and south of the lake. Construction of the Herbert Hoover Dike and the lowering of lake levels from a maximum of 20 to

17 ft NGVD effectively isolated thousands of acres of marsh, creating a new littoral zone/marsh community in areas where it had not previously existed.

- A variety of regulation schedules have been implemented on the lake to meet management objectives. In 1978, the maximum regulation stage was raised from 15.5 to 17.5 ft NGVD to obtain increased water storage capacity. In 1991, an interim regulation schedule (Run 25) was developed to better protect downstream estuaries from harmful lake regulation schedule discharges. Future changes are anticipated to address water supply and environmental issues.

Water Conservation Areas

- Construction of the C&SF Project coupled with large-scale urban and agricultural development of the LEC Planning Area have isolated large segments of original Everglades from the natural system by canals and levees. More than half of the original system has been lost to drainage and development (Davis and Ogden, 1994). Today, these developed areas support a variety of land uses, ranging from intensively managed agriculture in the north (EAA) to rapidly spreading urban areas located east of the WCAs.
- Loss of more than half of the original Everglades system to drainage and development has placed a fundamental limitation on the system's capacity to support populations of Everglades wildlife (i.e. wading birds, alligators, panthers) that once inhabited the area in much larger numbers.
- The three WCAs are now managed as surface water impoundments. As part of the C&SF Project, these areas serve multipurpose functions as follows:
    - Flood control for excess water discharged from Lake Okeechobee, the EAA, and coastal urban areas
    - Recharge for coastal ground water levels to prevent saltwater intrusion
    - Supplemental water supply for agriculture, municipal, and industrial use
    - Water supply for Everglades National Park
    - Fish and wildlife habitat
    - Public recreational use
- The WCAs no longer receive overland flow derived from upstream rainfall or overflow from Lake Okeechobee. These areas now depend primarily on direct rainfall, EAA runoff, and flood releases from Lake Okeechobee. These discharges have significantly altered the volume, timing, distribution, and quality of water in the WCAs. Altered flow

regimes and degraded water quality have also resulted in loss or degradation of native plant communities and associated wildlife habitat.

- Construction of levees and canals have impounded large areas of the WCA marshes resulting in the loss of natural overland flow, overdrainage of some areas and excessive flooding in other areas (USACE, 1994). Overdrainage has allowed terrestrial woody vegetation and introduced exotics such as melaleuca, Australian pine, and Brazilian pepper to replace native plant communities.
- Construction of the four major canals (North New River, Miami, Hillsboro, and West Palm Beach canals) through the central portion of the Everglades has resulted in over drainage of large areas (e.g., northern WCA-3A). These canals have reduced water depths and altered hydroperiods, reduced soil elevations, and formed subsidence valleys along the axis of the major canals. Construction of major roads such as Tamiami Trail (U.S. 41) and Alligator Alley (I-75) has impeded water flow south to the southern WCA-3A and Everglades National Park.
- WCA-2 and WCA-3 were originally constructed over portions of the Biscayne aquifer. Hydrologic studies indicate that these areas were too porous to hold water. Partitions WCA-2B and WCA-3B were created to reduce seepage losses.
- Water levels in the WCAs are now operated by regulation schedules which dictate when water management structures open and close. These schedules are driven primarily by two objectives: minimize flood risks during the hurricane season and maximize water storage during the dry season. As such, the WCAs function as surge tanks, which attempt to modulate the wide swings in flood and drought that are common to the region and attempt to maintain water levels and hydroperiods that will support sawgrass marshes, sloughs, and tree island communities that are indigenous to the region (Light and Dineen, 1994).

Holey Land and Rotenberger Wildlife Management Areas

- Construction of the Miami Canal and impoundment of the Holey Land and Rotenberger WMAs by a levee system has cut off historical sheetflow and altered the hydrology of both WMAs (much drier than historical conditions).
- By the late 1960s these hydrological changes in combination with conversion of some portions of the marsh to farmland has significantly lowered water levels and altered hydroperiod. These hydrologic changes have resulted in severe muck fires, loss of tree islands, loss of peat soils, and conversion of native sawgrass communities to terrestrial brush vegetation.

- Numerous artificial muck islands were constructed by the FFWCC in the 1970s in an attempt to help mitigate the loss of tree islands and wildlife impacted by muck fires (Schortemeyer, 1980).

Everglades National Park

- In Everglades National Park, uncontrolled flows to Shark River Slough have been impeded by construction of Tamiami Trial (U.S. 41) across the Everglades in 1928. Construction of the eastern perimeter levee and impoundment of the upstream WCAs, as part of the C&SF Project, essentially eliminated natural sheetflow to Shark River Slough by the mid 1950s. Current flow patterns to Everglades National Park are highly influenced by upstream management of the WCAs and pumping of agricultural and urban drainage canals to the north and east.
- Construction of the L-67A Canal now diverts much more water into western Shark River Slough as compared to historical conditions. East of L-67A, historical flows into Everglades National Park via northeast Shark River Slough have been significantly altered as a result of construction of L-29, WCA-3B, and the eastern perimeter levee. This area now has significantly less flow as compared to predrainage conditions and exhibits shorter hydroperiods, shallower water depths, and more frequent drawdowns as compared to predrainage conditions.
- Agricultural and urban development in the east Everglades has resulted in the loss of marl-forming wet prairies through conversion of marshes to farmland and housing projects. Construction of the South Dade Conveyance System (L-31N and L-31W) caused compartmentalization and overdrainage of remaining marl prairies in the Rocky Glades and northern Taylor Slough headwaters. This water management system has altered hydropatterns and lowered water tables throughout eastern Everglades National Park and has reduced flows to Florida Bay.

Biscayne Aquifer

- The Biscayne aquifer provides most of the fresh water for public water supply and agriculture within the LEC Planning Area.
- Construction of the north-south perimeter levee and subsequent lowering of water levels in coastal canals east of the Everglades to provide flood protection for development, have resulted in an overall lowering of the ground water table four to five feet below historical levels.
- The Biscayne aquifer is one of the most permeable aquifers in the world and is highly susceptible to saltwater intrusion.
- Lowering of the ground water table to provide drainage, increased water withdrawals from wellfields, and construction of the major coastal canals has allowed salt water to invade and contaminate large areas of the Biscayne aquifer during periods of drought.

- Water levels in coastal canals provide a direct indication of water levels in the adjacent aquifer and are indirectly related to chloride concentrations in monitoring wells. Historical data indicate that when water levels in the canals and aquifer remain low for more than six months, significant inland migration of the freshwater/saltwater interface may occur.